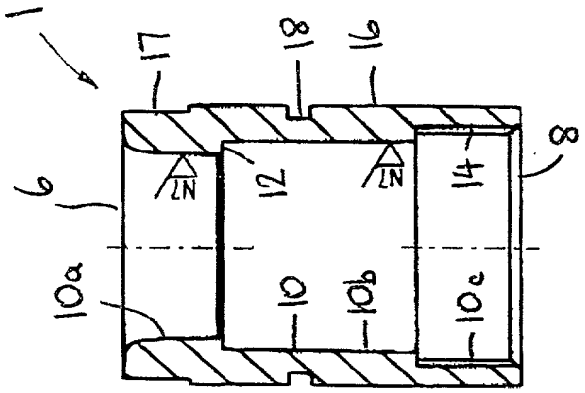


FIG. 2

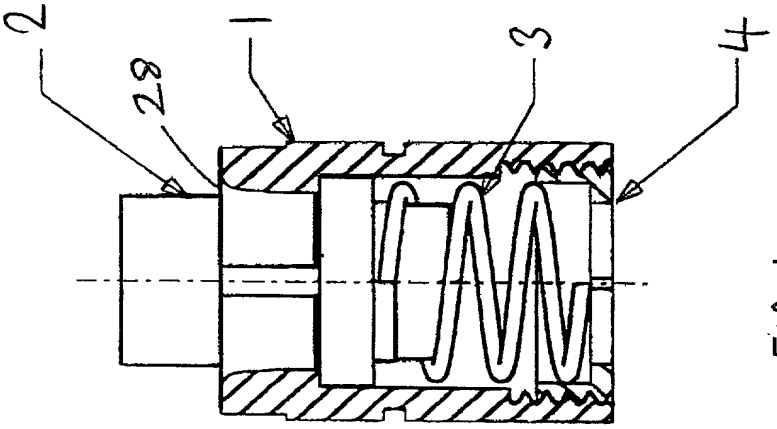


FIG. 1

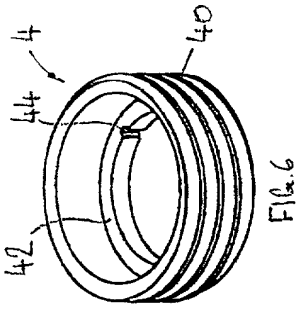


FIG.6

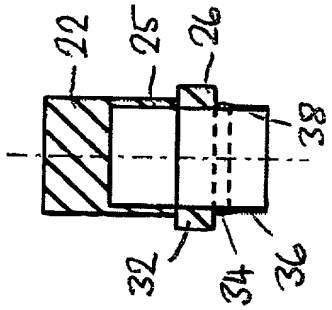


FIG.4

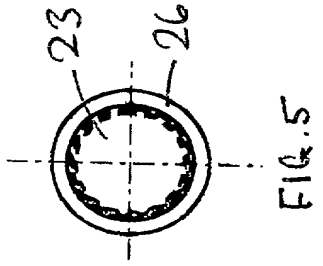


FIG.5

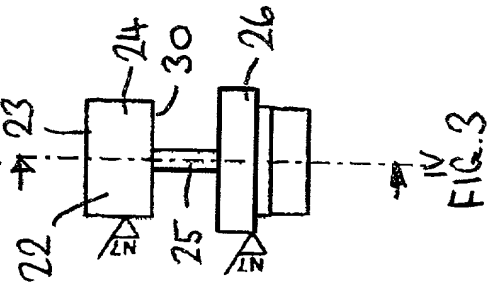
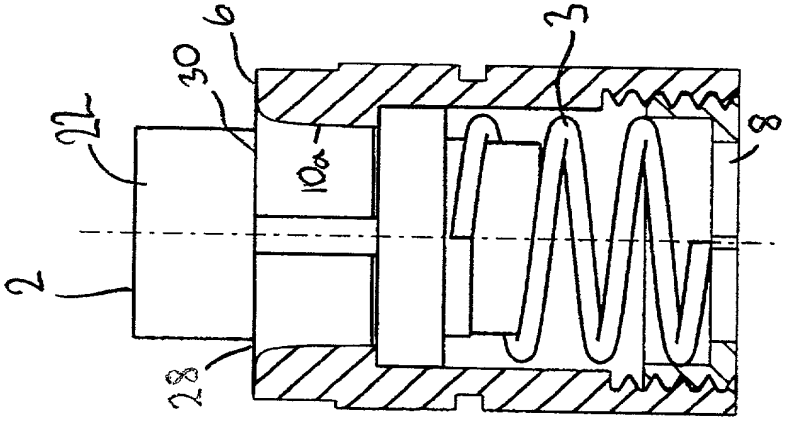
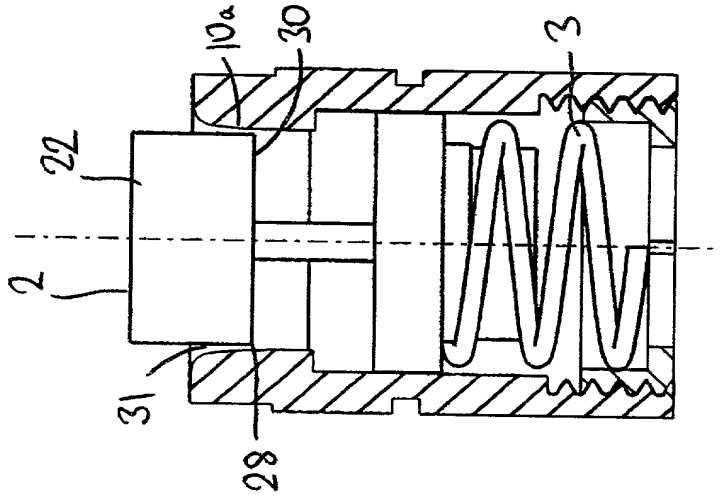


FIG.3



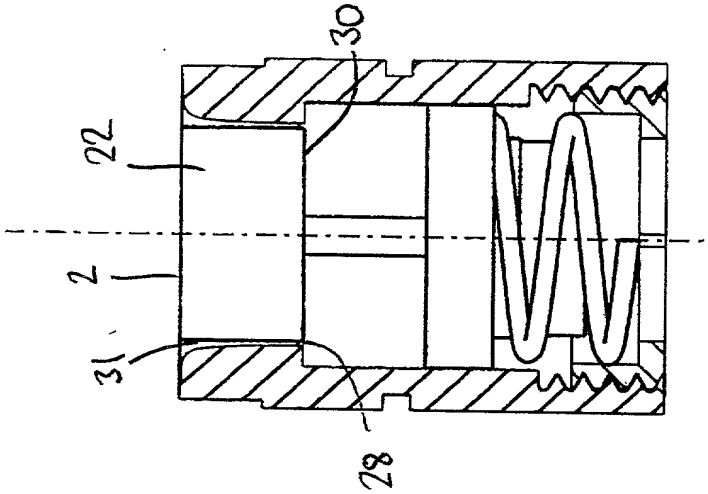
A) POSITION :- FULLY OPEN

Fig. 7



B) POSITION :- INTERMEDIATE OPEN

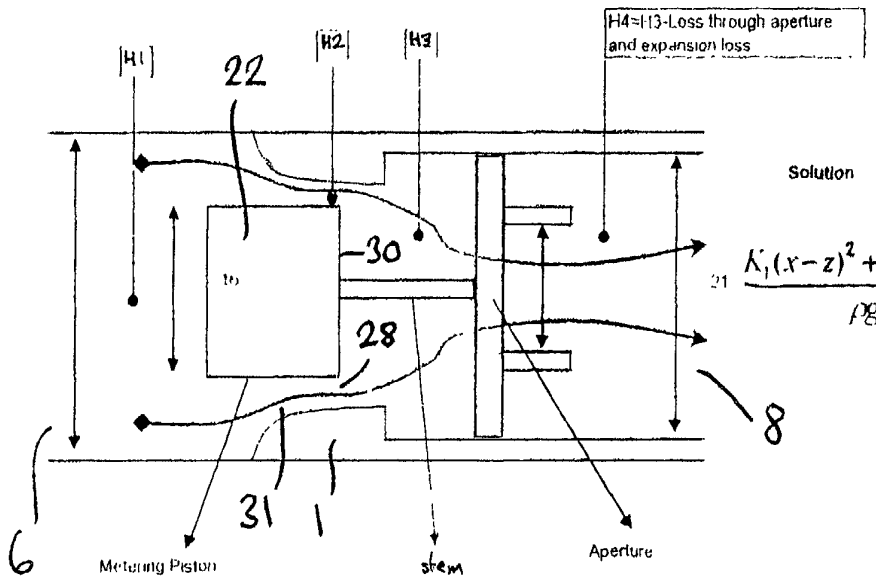
Fig. 8



C) POSITION :- FULLY CLOSED

Fig. 9

$$\frac{K_1(x-z)^2 + K_2(x-z)}{\rho g} = A_p(H_4 - H_3) - A_{base}(H_3 - H_4)$$



Solution

$$\frac{K_1(x-z)^2 + K_2(x-z)}{\rho g} = A_p(H_1 - H_4) - \frac{Q^2}{2gA_p^2}(A_p - A_b)(1 - \frac{A_p^2}{A_b^2})^2$$

Fig. 10

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TYPICAL TRUMPET SIZES vs FLOW RATE

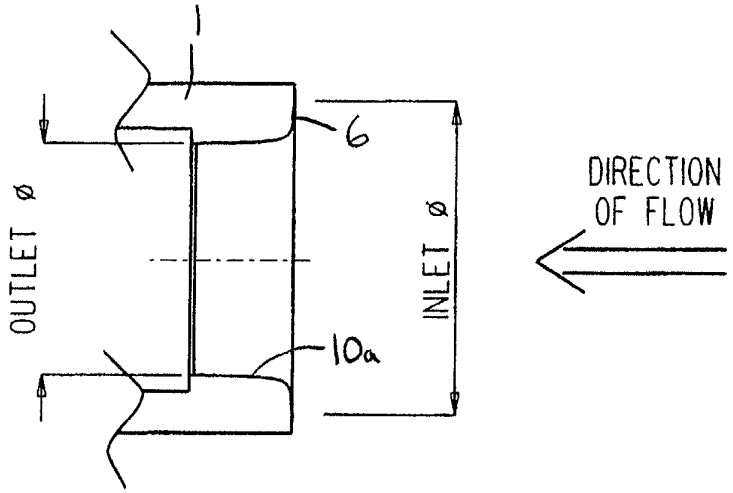


Fig. 11

SIZE	INLET DIA	OUTLET DIA	FLOW RATE l/s
3/4"	26.750	17.474	0.221
3/4"	26.626	19.059	1.199
1 1/4"	33.271	23.679	0.758
1 1/4"	31.422	24.357	1.263
2"	45.556	31.385	1.263
2"	45.575	33.343	3.157
3"	67.979	45.665	7.261

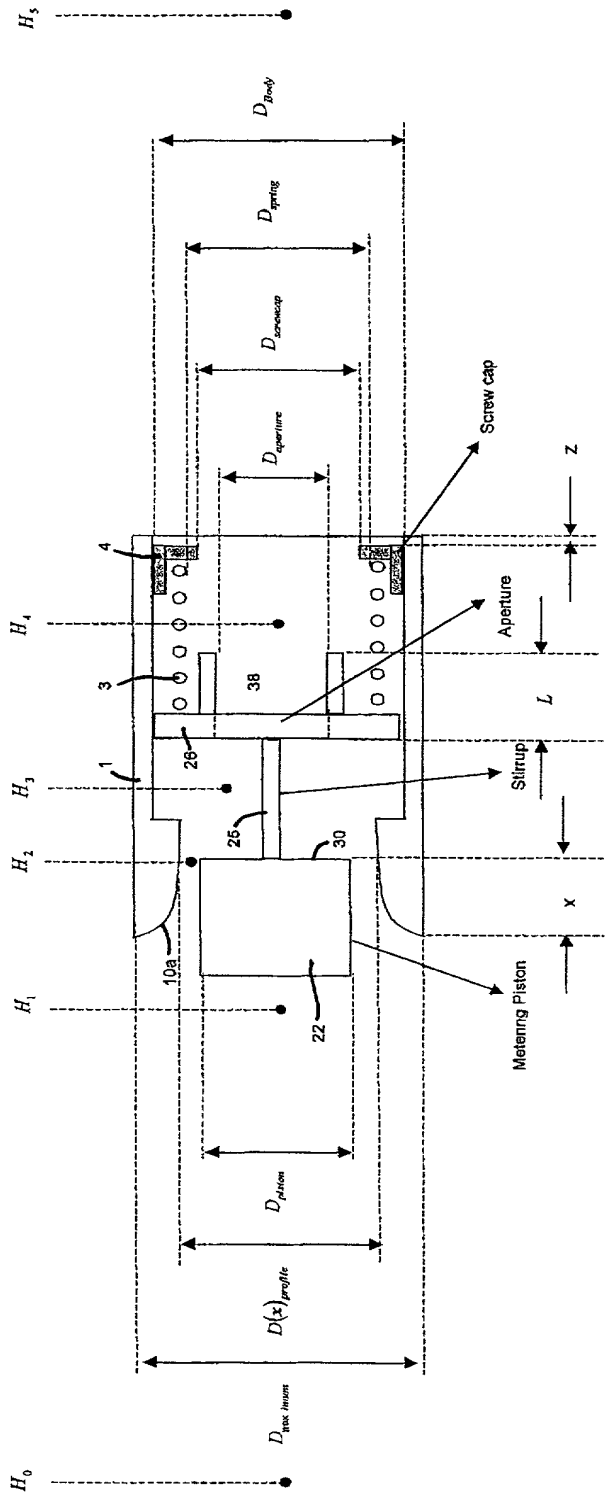

H_5
H_4
H_3
H_2
H_1
H_0
D_{Body}
D_{spring}
$D_{screwcap}$
$D_{aperture}$
D_{piston}
$D(x)_{profile}$
$D_{max\ insert}$
Screw cap
Aperture
Stirrup
Metering Piston
z
L
x
4
3
38
28
1
25
30
10a
22

FIGURE 12

Force balance

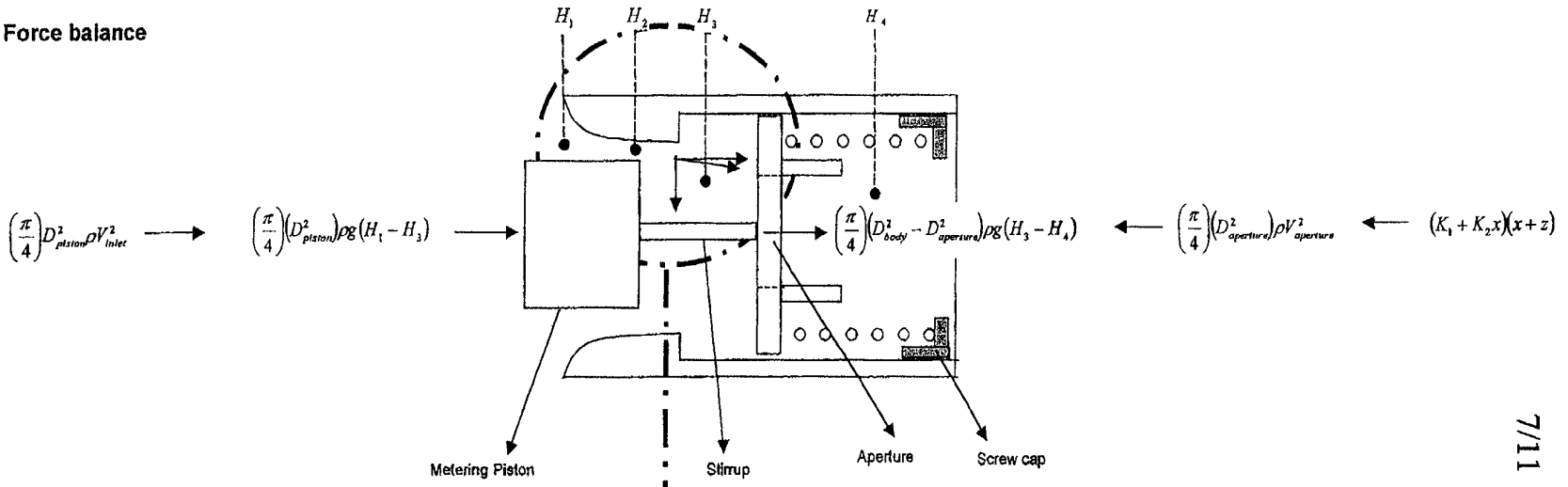


FIGURE 13

Force exerted by the emergent annular jet

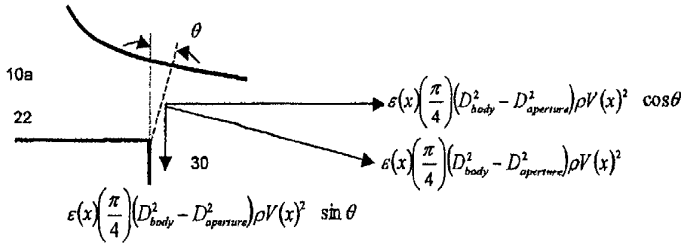


FIGURE 14

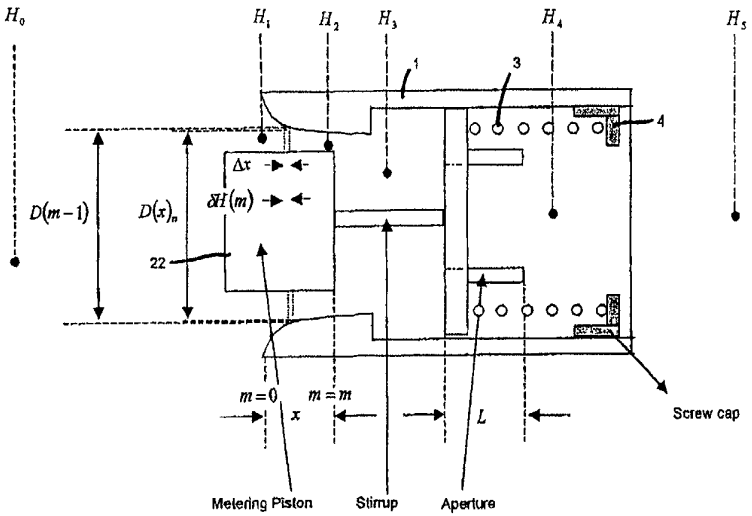


FIGURE 15

$$\delta H(m) = 0.13125\left[f(x)_n - f(m-1)\right]\frac{\Delta x_m}{\frac{(D(x)_n + D(m-1))}{2} - D_{piston}}\frac{V(x)_n^2 + V^2(m-1)}{g}$$

where $f_x = \dfrac{0.25}{\left[\log\left(\dfrac{k_{profile}}{3.7\left(D(x)_{profile} - D_{piston}\right)} + \dfrac{5.74}{\mathrm{Re}(x)^{0.9}}\right)\right]^2}$ & $\mathrm{Re}(x) = \dfrac{V(x)\left(D(x)_{profile} - D_{piston}\right)}{\nu}$

$$H_1 - H_2 = \sum_{m=0}^{m}\delta H(m)$$

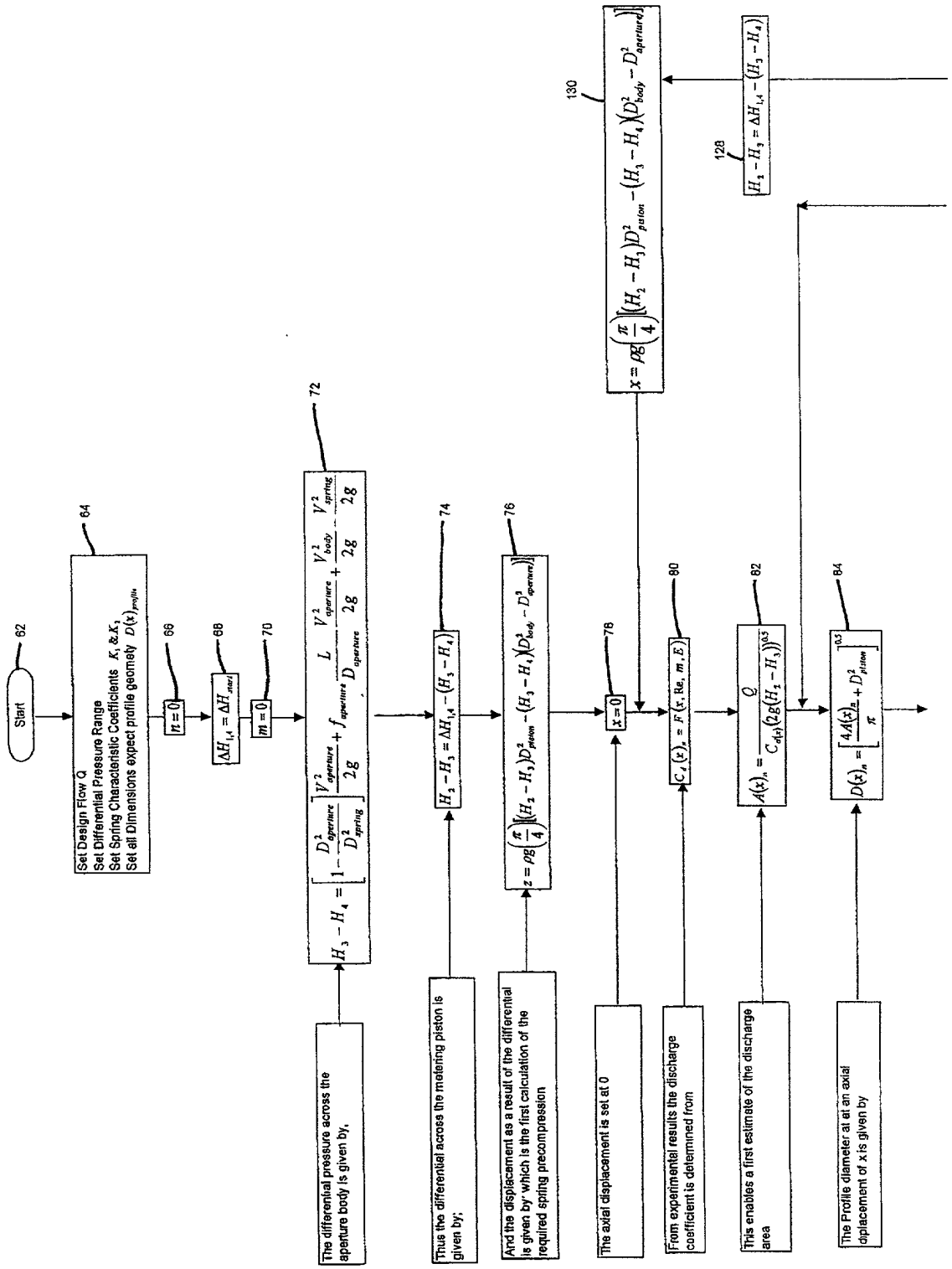
$$H_2 - H_3 = \frac{1}{2g}\left[\frac{Q}{C_d(x)\frac{\pi}{4}\left(D(x)_{profile}^2 - D_{piston}^2\right)}\right]^2$$

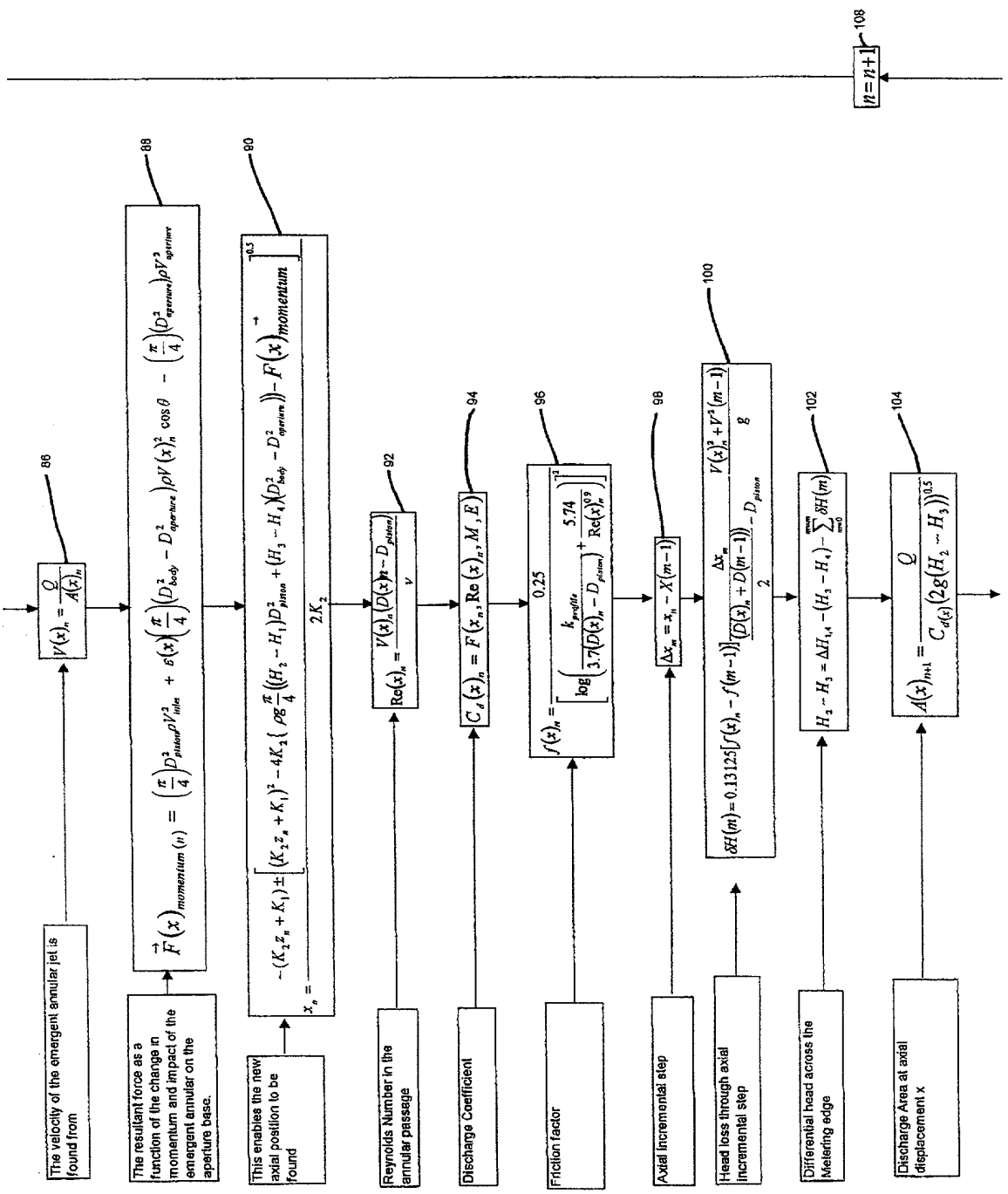
$$H_3 - H_4 = \left[1 - \frac{D_{aperture}^2}{D_{spring}^2}\right]\frac{V_{aperture}^2}{2g} + f_{aperture}\frac{L}{D_{aperture}}\frac{V_{aperture}^2}{2g} + \frac{V_{body}^2}{2g} - \frac{V_{spring}^2}{2g}$$

where. $f_{aperture} = \dfrac{0.25}{\left[\log\left(\dfrac{k_{aperture}}{3.7D_{aperture}} + \dfrac{5.74}{\mathrm{Re}_{aperture}^{0.9}}\right)\right]^2}$ & $\mathrm{Re}_{aperture} = \dfrac{V_{aperture}D_{aperture}}{\nu}$

$$H_5 = H_4 + C_p(x)\frac{V_{screwcap}^2}{2g}$$

$$H_0 - H_1 = \zeta\frac{V_{pipe}^2}{2g}$$


Start
62
Set Design Flow Q
Set Differential Pressure Range
Set Spring Characteristic Coefficients K, &K,
Set all Dimensions expect profile geometry $D(x)_{profile}$
64
n = 0
66
$\Delta H_{1,4} = \Delta H_{start}$
68
m = 0
70
$H_3 - H_4 = \left[1 - \frac{D^2_{aperture}}{D^2_{spring}}\right]\frac{V^2_{aperture}}{2g} + f_{aperture}\frac{L}{D_{aperture}}\frac{V^2_{aperture}}{2g} + \frac{V^2_{body}}{2g} - \frac{V^2_{spring}}{2g}$
72
The differential pressure across the aperture body is given by,
$H_2 - H_3 = \Delta H_{1,4} - (H_3 - H_4)$
74
Thus the differential across the metering piston is given by;
$z = \rho g\left(\frac{\pi}{4}\right)\left[(H_2 - H_3)D^2_{piston} - (H_3 - H_4)(D^2_{body} - D^2_{aperture})\right]$
76
And the displacement as a result of the differential is given by: which is the first calculation of the required spring precompression
x = 0
78
The axial displacement is set at 0
$C_d(x)_n = F(x, Re, m, E)$
80
From experimental results the discharge coefficient is determined from
$A(x)_n = \frac{Q}{C_{d(x)}\sqrt{2g(H_2 - H_3)}}$
82
This enables a first estimate of the discharge area
$D(x)_n = \left[\frac{4A(x)_n}{\pi} + D^2_{piston}\right]^{0.5}$
84
The Profile diameter at at an axial displacement of x is given by
$x = \rho g\left(\frac{\pi}{4}\right)\left[(H_2 - H_3)D^2_{piston} - (H_3 - H_4)(D^2_{body} - D^2_{aperture})\right]$
130
$H_2 - H_3 = \Delta H_{1,4} - (H_3 - H_4)$
128


The velocity of the emergent annular jet is found from
$V(x)_n = \frac{Q}{A(x)_n}$
86
The resultant force as a function of the change in momentum and impact of the emergent annular on the aperture base.
$\vec{F}(x)_{momentum}(n) = \left(\frac{\pi}{4}\right)D^2_{piston}\rho V^2_{inlet} + \varepsilon(x)\left(\frac{\pi}{4}\right)\left(D^2_{body} - D^2_{aperture}\right)\rho V(x)^2_n \cos\theta - \left(\frac{\pi}{4}\right)\left(D^2_{aperture}\right)\rho V^2_{aperture}$
88
This enables the new axial position to be found
$x_n = \frac{-(K_2 z_n + K_1) \pm \left[(K_2 z_n + K_1)^2 - 4K_2\left\{\rho g \frac{\pi}{4}\left((H_2 - H_1)D^2_{piston} + (H_3 - H_4)\left(D^2_{body} - D^2_{aperture}\right)\right) - F(x)^{\rightarrow}_{momentum}\right\}^{0.5}\right]}{2K_2}$
90
Reynolds Number in the annular passage
$\mathrm{Re}(x)_n = \frac{V(x)_n\left(D(x)_n - D_{piston}\right)}{\nu}$
92
Discharge Coefficient
$C_d(x)_n = F(x_n, \mathrm{Re}(x)_n, M, E)$
94
Friction factor
$f(x)_n = \frac{0.25}{\left[\log\left(\frac{k_{profile}}{3.7\left(D(x)_n - D_{piston}\right)} + \frac{5.74}{\mathrm{Re}(x)_n^{0.9}}\right)\right]^2}$
96
Axial incremental step
$\Delta x_m = x_n - X(m-1)$
98
Head loss through axial incremental step
$\delta H(m) = 0.13125\left[f(x)_n - f(m-1)\right]\frac{\Delta x_m}{\frac{\left(D(x)_n + D(m-1)\right)}{2} - D_{piston}}\frac{V(x)_n^2 + V^2(m-1)}{g}$
100
Differential head across the Metering edge
$H_2 - H_3 = \Delta H_{1,4} - (H_3 - H_4) - \sum_{m=0}^{m=n}\delta H(m)$
102
Discharge Area at axial displacement x
$A(x)_{n+1} = \frac{Q}{C_{d(x)}\left(2g\left(H_2 - H_3\right)\right)^{0.5}}$
104
$n = n+1$
108

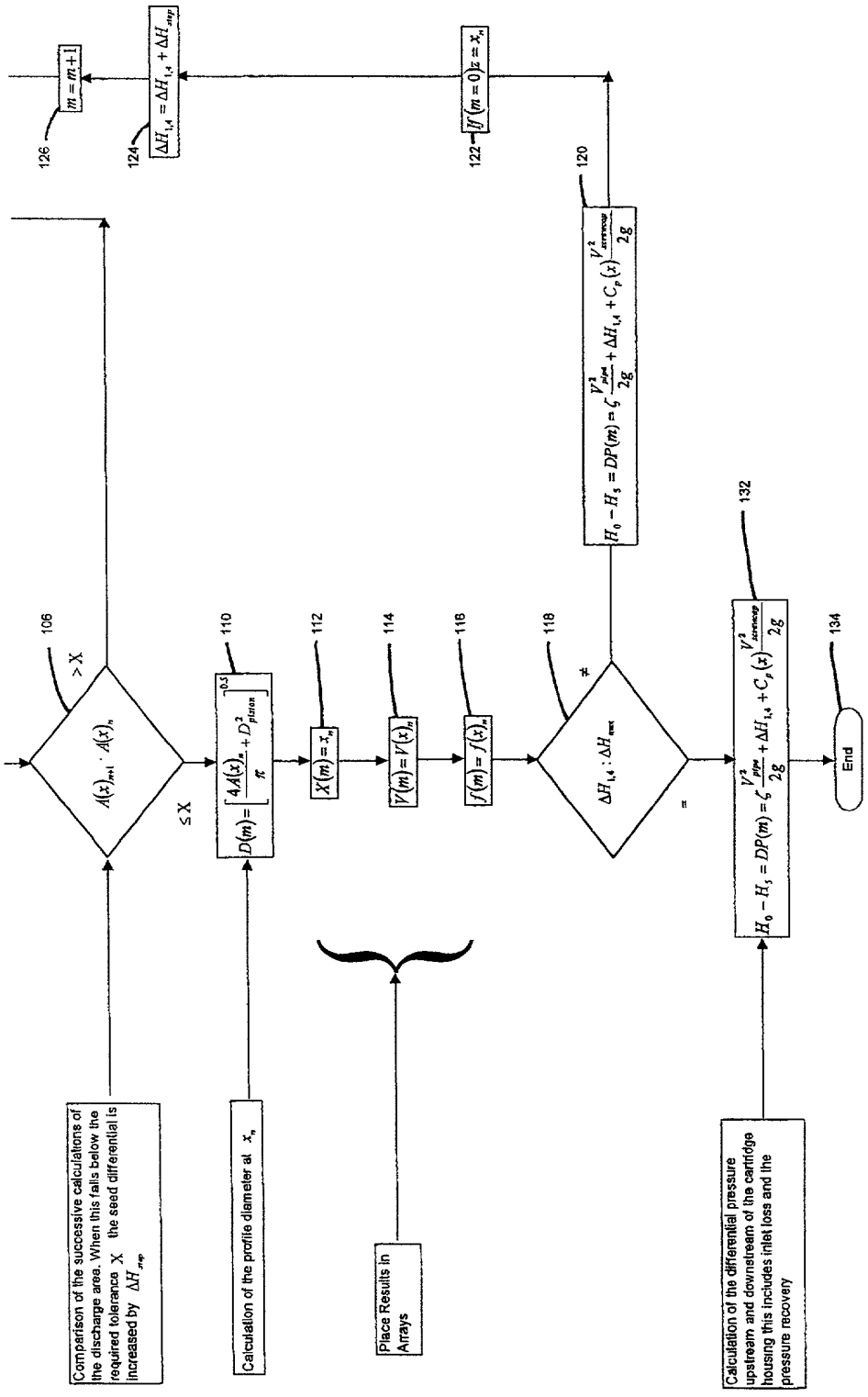

Comparison of the successive calculations of the discharge area. When this falls below the required tolerance X the seed differential is increased by ΔH_{step}
Calculation of the profile diameter at x_n
Place Results in Arrays
Calculation of the differential pressure upstream and downstream of the cartridge housing this includes inlet loss and the pressure recovery
$A(x)_{n+1} \cdot A(x)_n$
> X
≤ X
$D(m) = \left[\frac{4A(x)_n}{\pi} + D_{piston}^2\right]^{0.5}$
$X(m) = x_n$
$V(m) = V(x)_n$
$f(m) = f(x)_n$
$\Delta H_{1,4} : \Delta H_{set}$
≠
=
$H_0 - H_5 = DP(m) = \zeta \frac{V_{pipe}^2}{2g} + \Delta H_{1,4} + C_p(x) \frac{V_{annulus}^2}{2g}$
$H_0 - H_5 = DP(m) = \zeta \frac{V_{pipe}^2}{2g} + \Delta H_{1,4} + C_p(x) \frac{V_{annulus}^2}{2g}$
End
$If(m = 0)x = x_n$
$\Delta H_{1,4} = \Delta H_{1,4} + \Delta H_{step}$
$m = m+1$
106
110
112
114
116
118
120
122
124
126
132
134

FIGURE 16